Overview of Combined Heat & Power

EVER-GREEN ENERGY™

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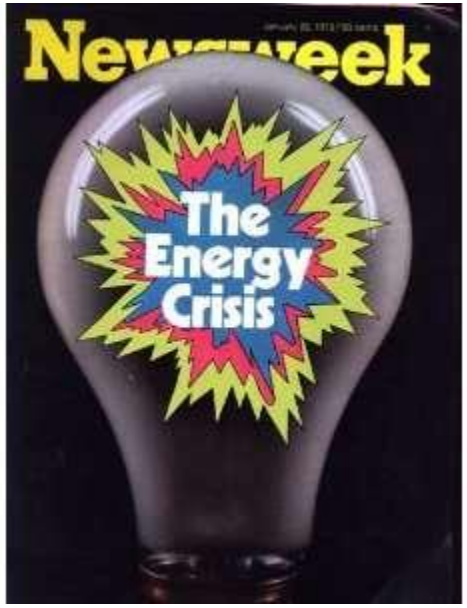
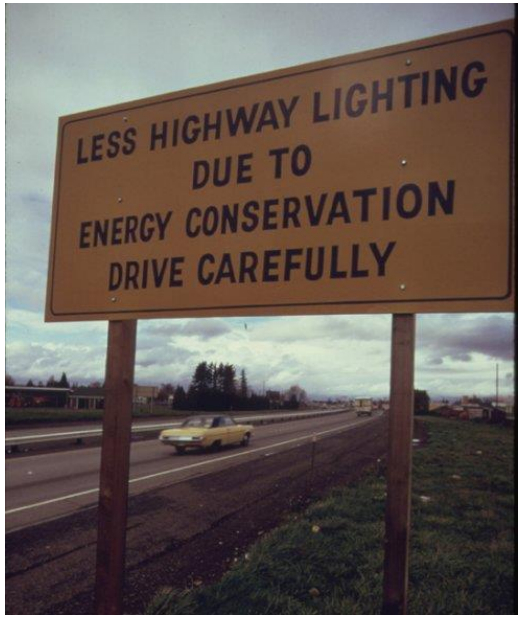
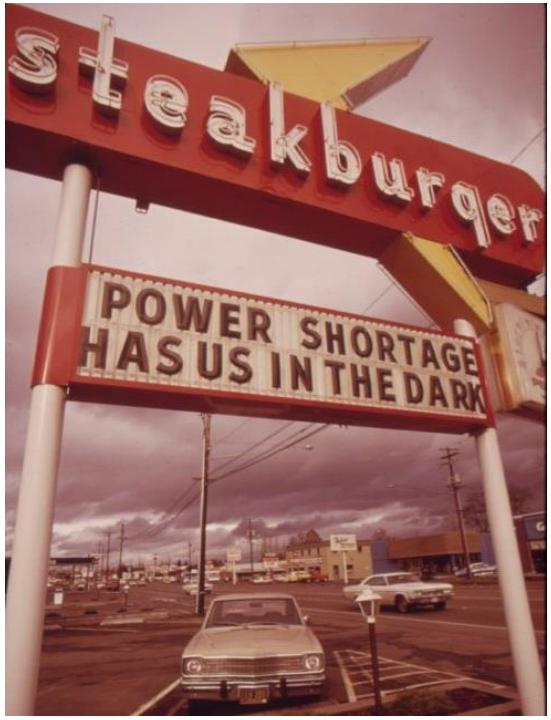
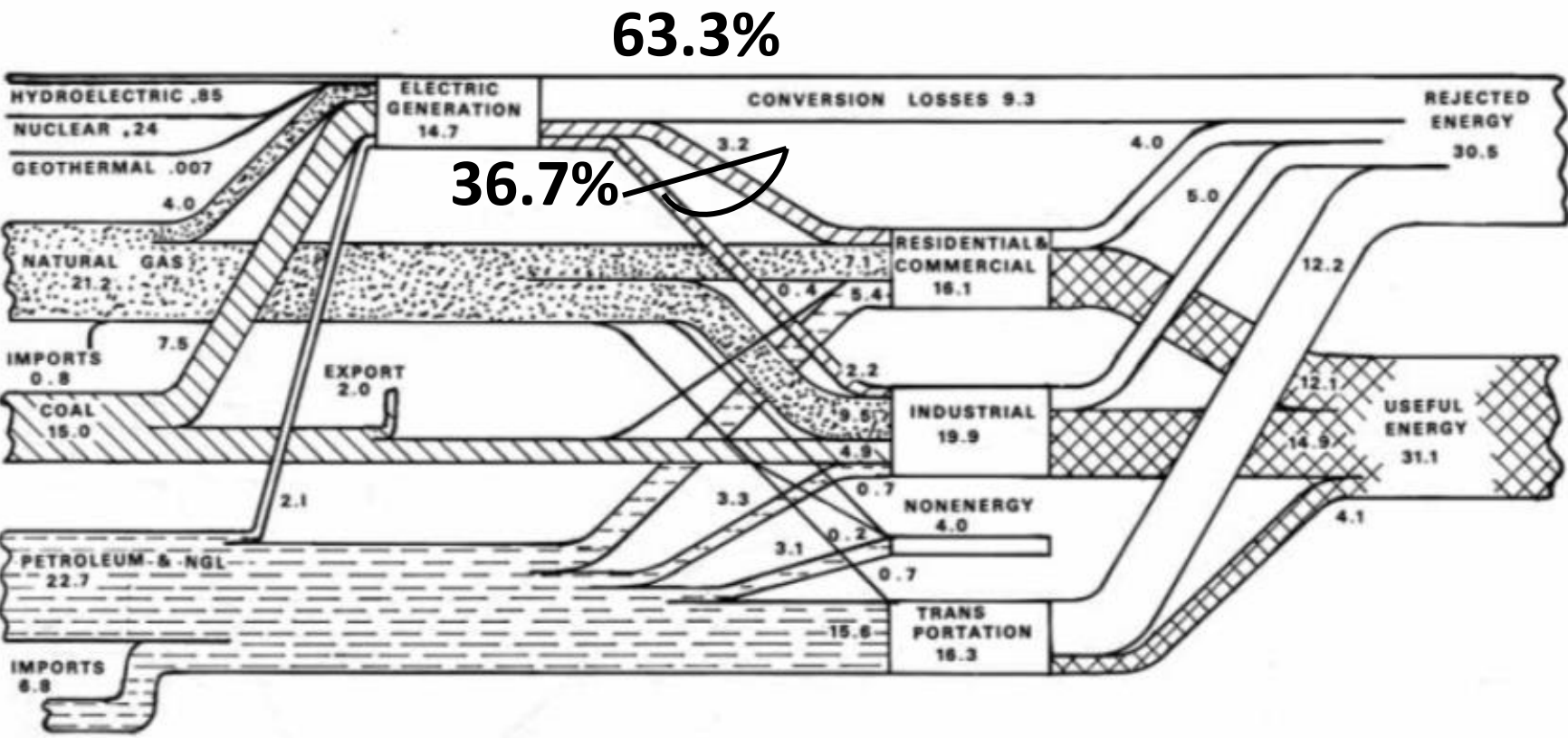
SPEED
LIMIT
55
It's a law
we can


The
Energy
Crisis


LESS HIGHWAY LIGHTING
DUE TO
ENERGY CONSERVATION
DRIVE CAREFULLY


steakburger
POWER SHORTAGE
HAS US IN THE DARK



U.S. Energy Flow — 1970

All values X 10^{15} Btu (2.12 X 10^{15} Btu = 10^{6} bbl/day oil)

Total energy consumption = 67.5 X 10^{15} Btu

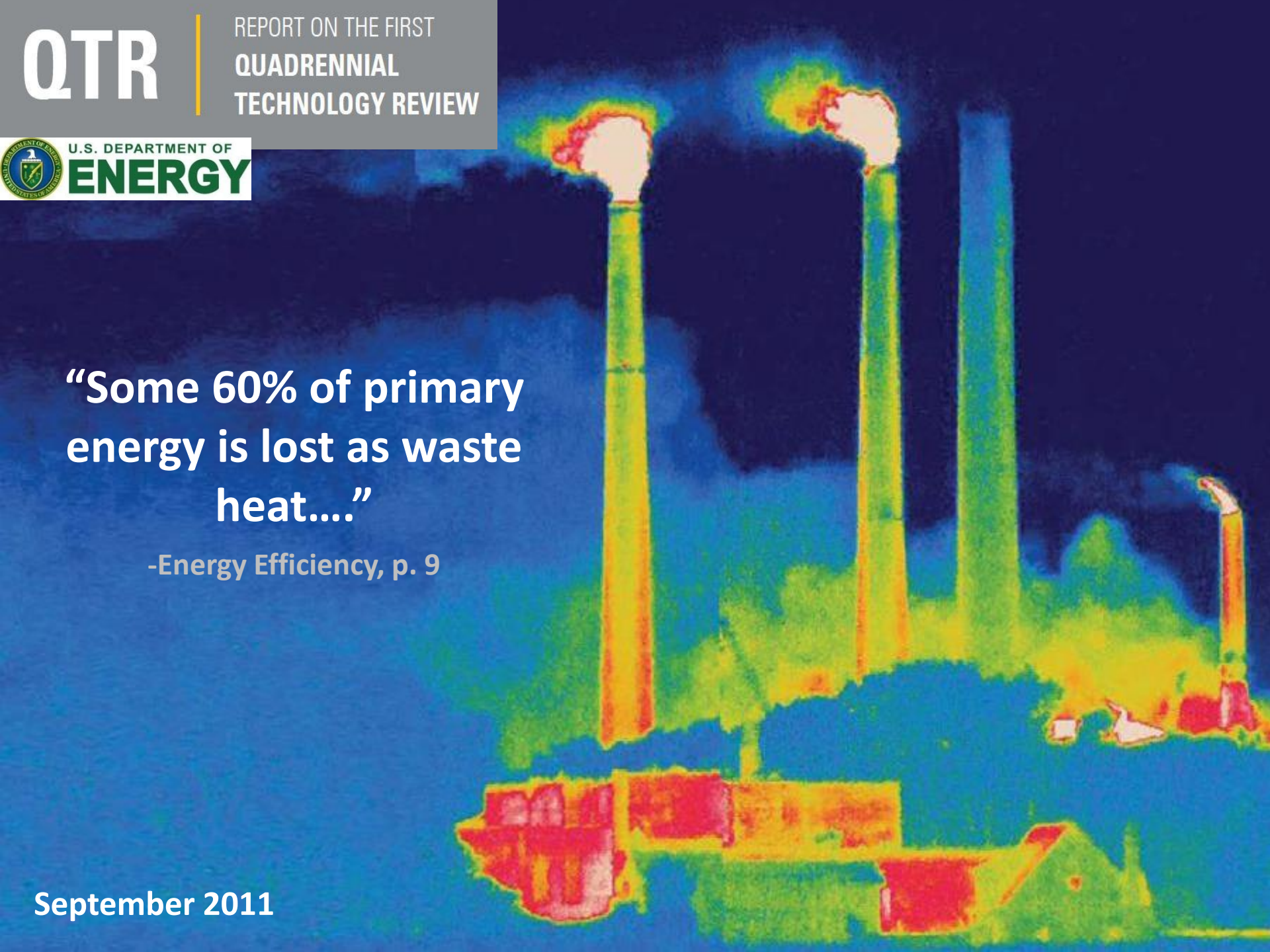
LAWRENCE LIVERMORE LABORATORY

Source: https://flowcharts.llnl.gov/

QTR

REPORT ON THE FIRST
QUADRENNIAL
TECHNOLOGY REVIEW

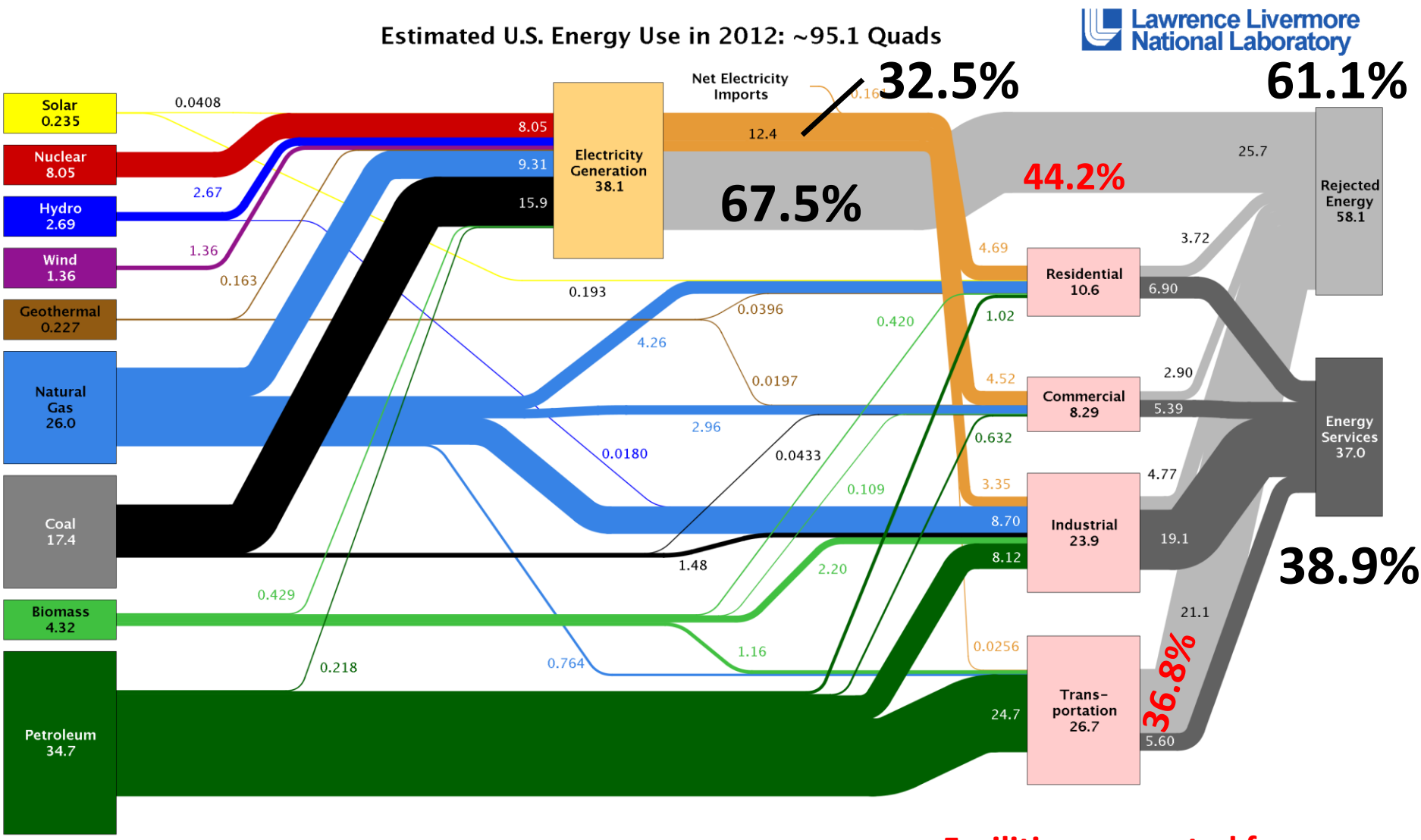
U.S. DEPARTMENT OF ENERGY



"Some 60% of primary energy is lost as waste heat…."

-Energy Efficiency, p. 9

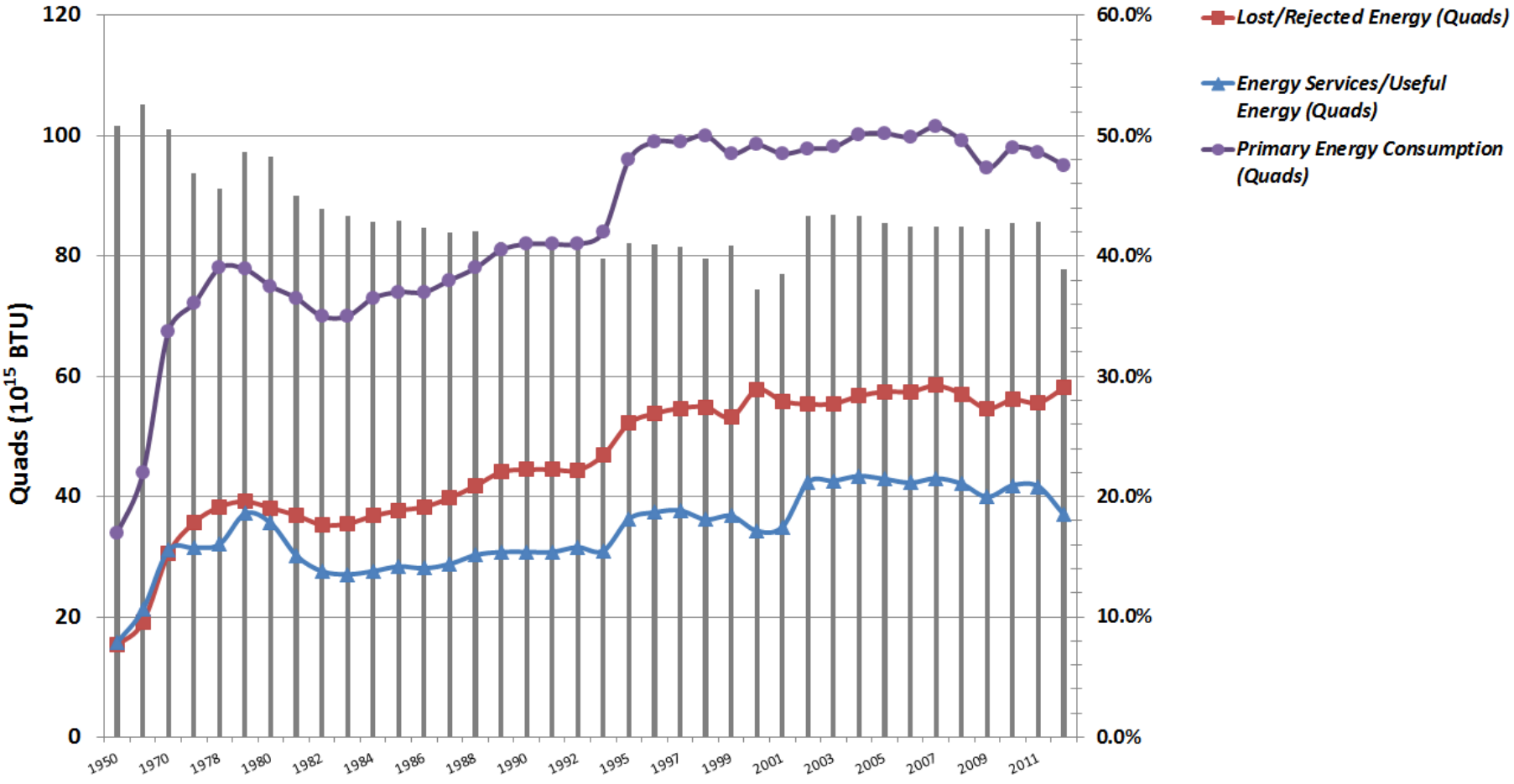
September 2011



Source: https://flowcharts.llnl.gov

US Energy Usage and System Efficiency
1950 - 2012

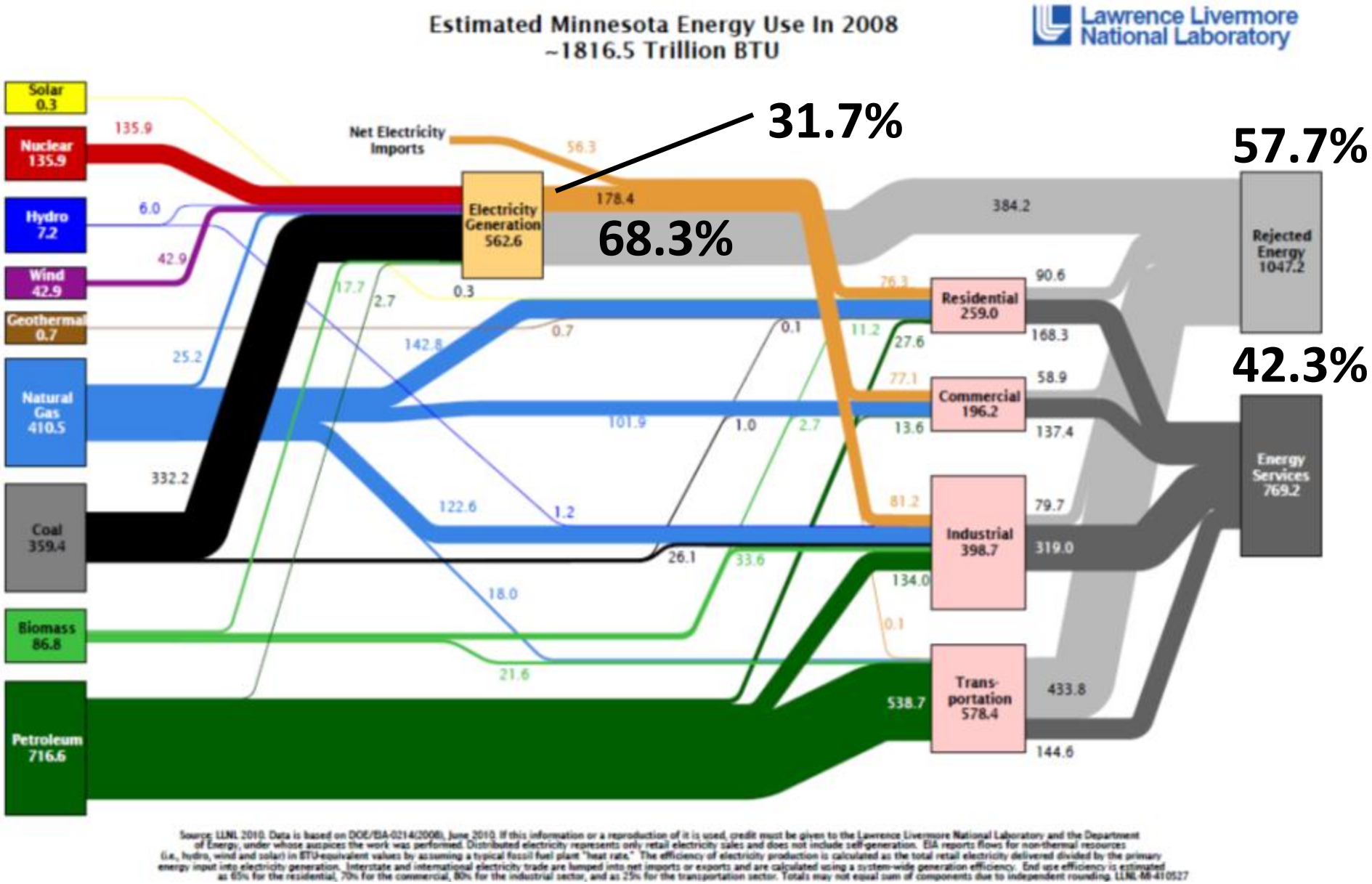
Efficiency = Rejected Energy/(Energy Services + Rejected Energy)



Source: Data from Lawrence Livermore National Laboratory Energy Flow Diagrams
https://flowcharts.llnl.gov/index.html

Minnesota Energy Profile

- Minnesota uses a lot of energy
  - Over 1,800 Trillion BTU's in primary energy annually (10^{12})
- Minnesota is essentially dependent on energy imported from other states and countries
  - 100% of coal and uranium are imported
  - 100% of oil & petroleum products are imported
  - 100% of natural gas is imported
- Using energy efficiently benefits Minnesota's residents, economy and environment



Source: https://flowcharts.llnl.gov/

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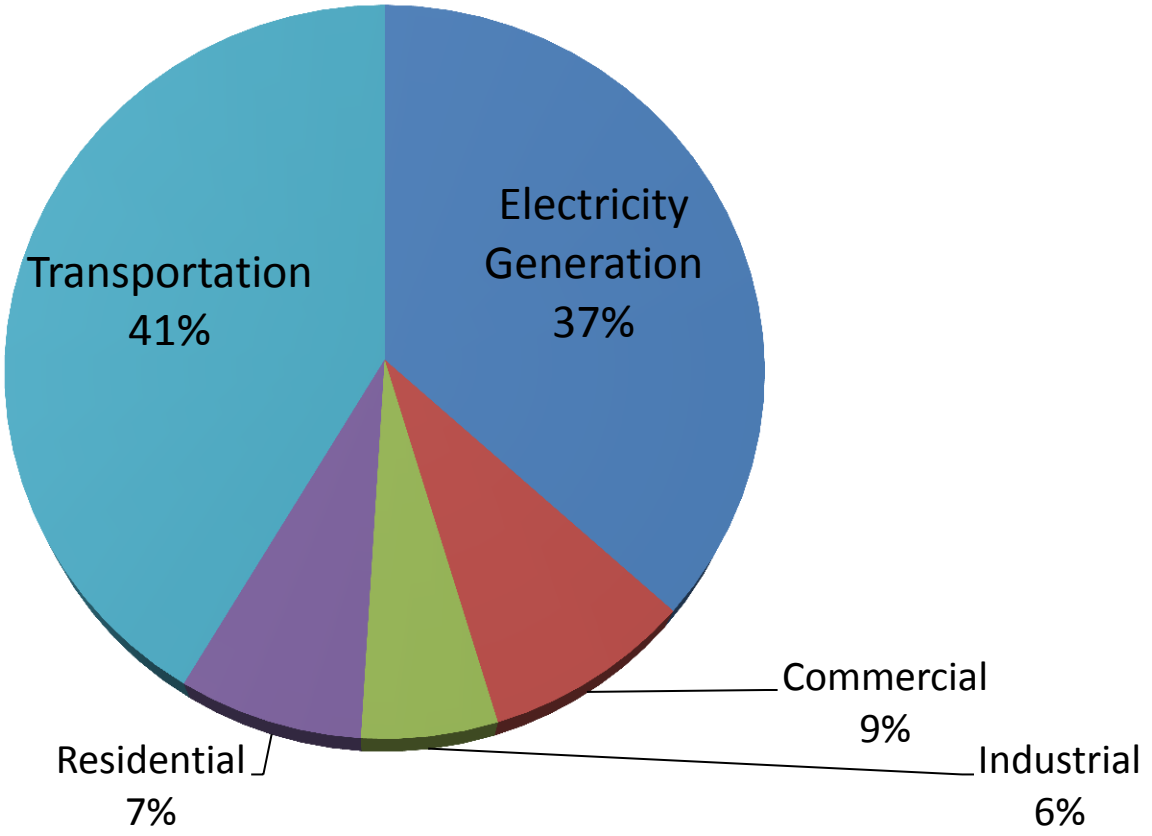
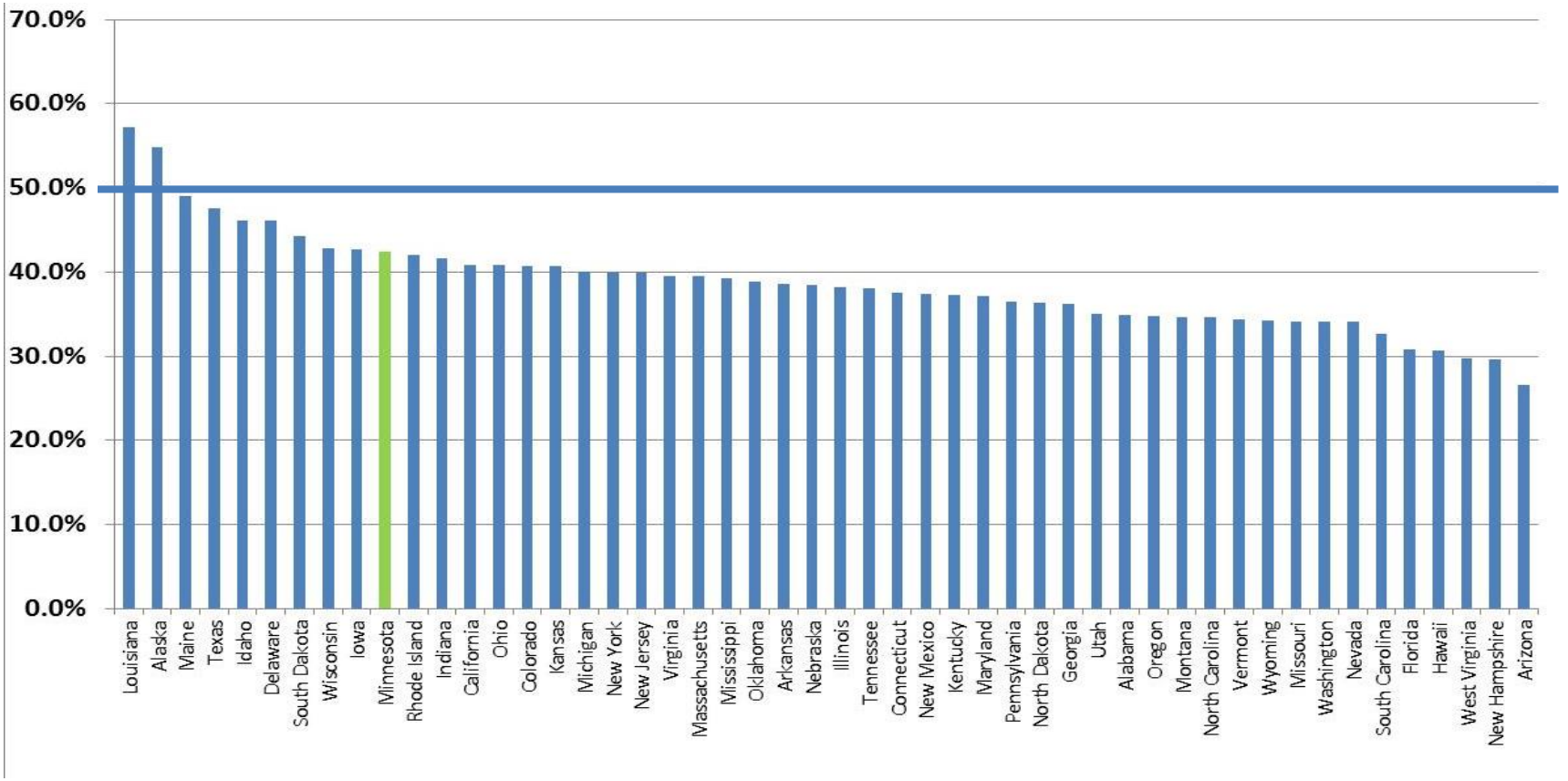
MN 2008 Rejected/Lost Energy

1,047.2 Trillion BTU



Source: Data from Lawrence Livermore National Laboratory Energy Flow Diagrams - https://flowcharts.llnl.gov/index.html

Comparison of 2008 State System Efficiency

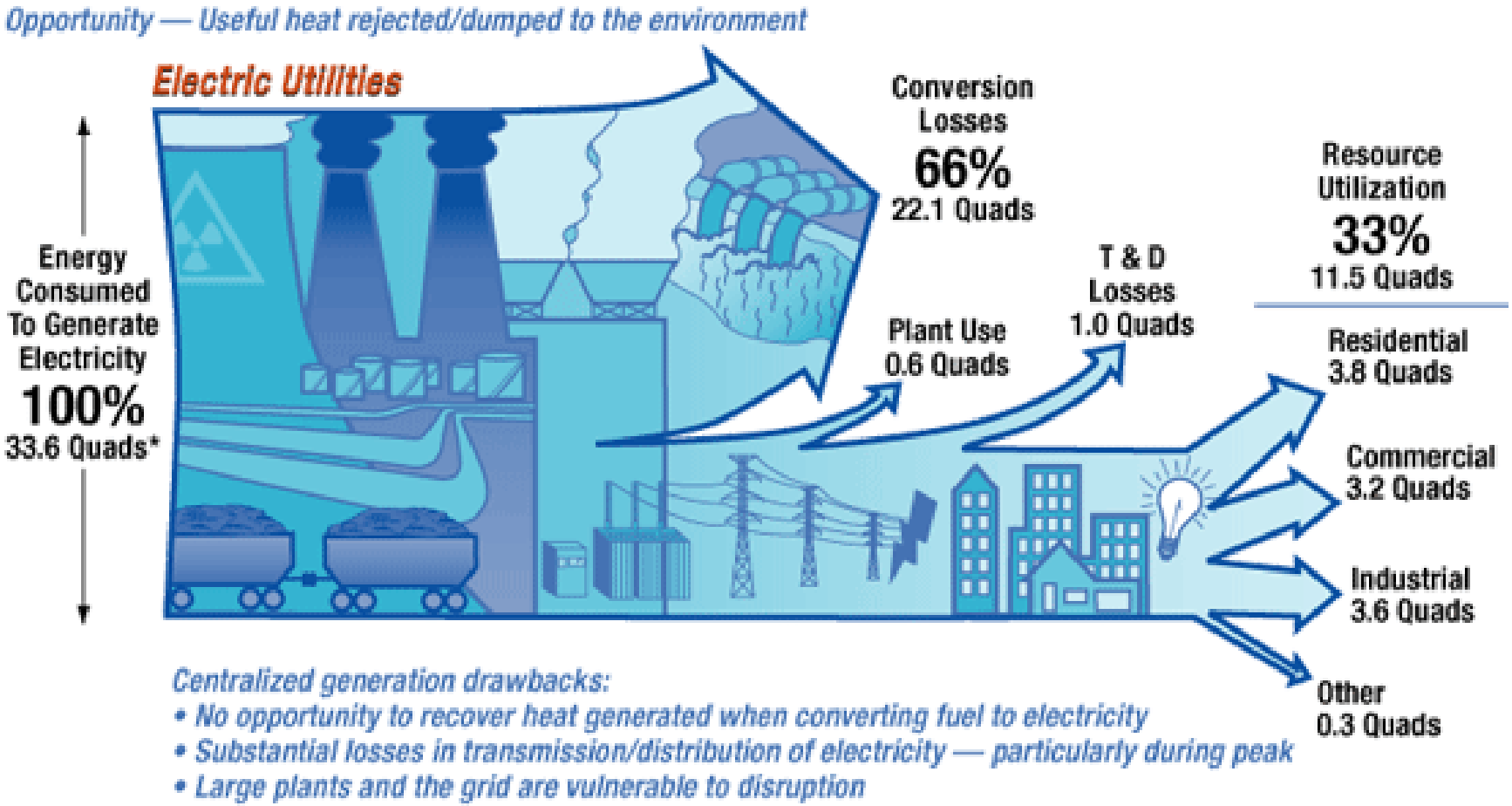


Efficiency = useful energy/(useful energy + rejected lost)

Source: Data from Lawrence Livermore National Laboratory Energy Flow Diagrams - https://flowcharts.llnl.gov/index.html

Opportunities

Current U.S. Electricity System

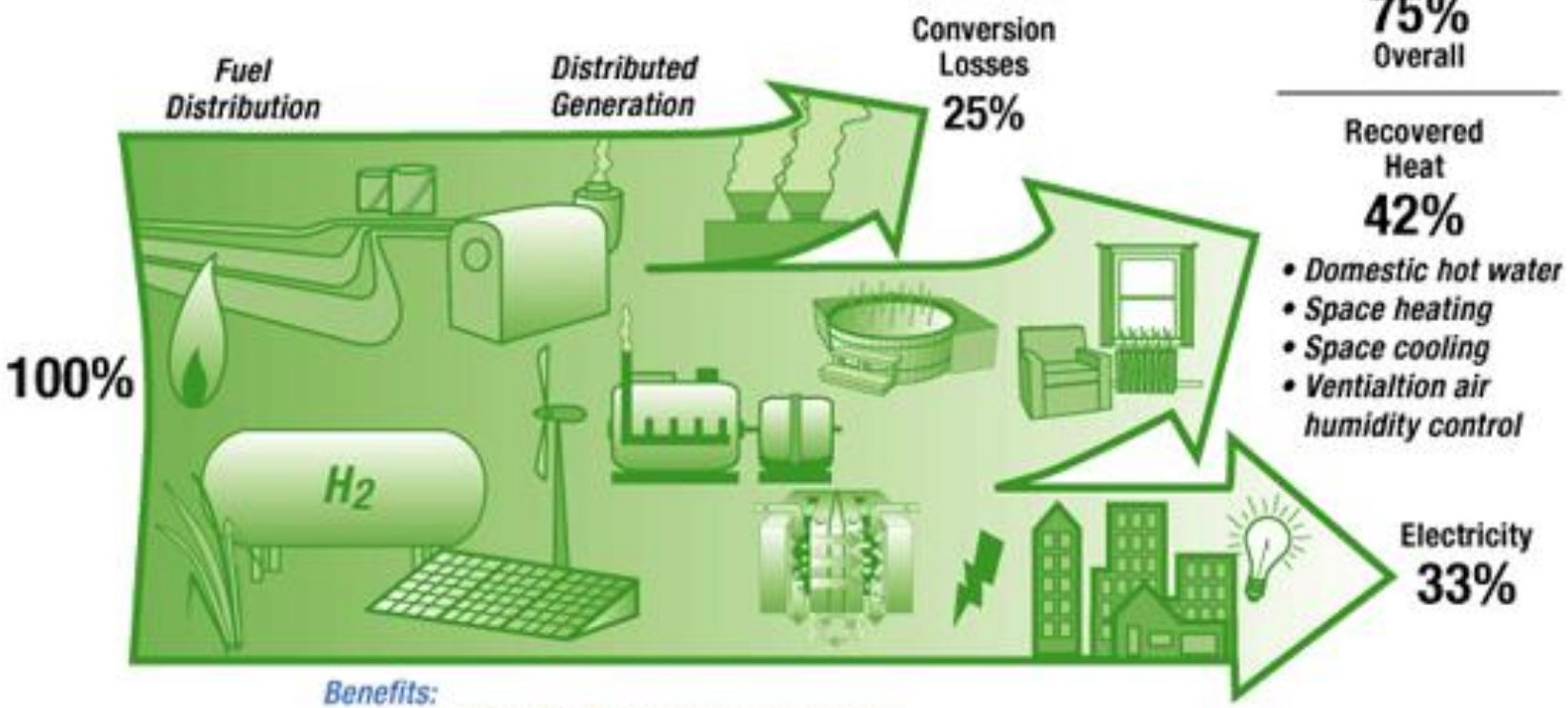


*Quads — Quadrillion Btu's

Source: NREL http://www.nrel.gov/dtet/about.html

Opportunity: Generate Heat and Power

Combined heat and power solution to recycling waste heat:
Distribute electricity generation to where waste heat can be recovered and put to use.



Benefits:
- *More efficient use of our natural resources*
- *More secure against natural and man-made disasters*
- *Reduced pollution*
- *Enhanced indoor air quality and comfort*

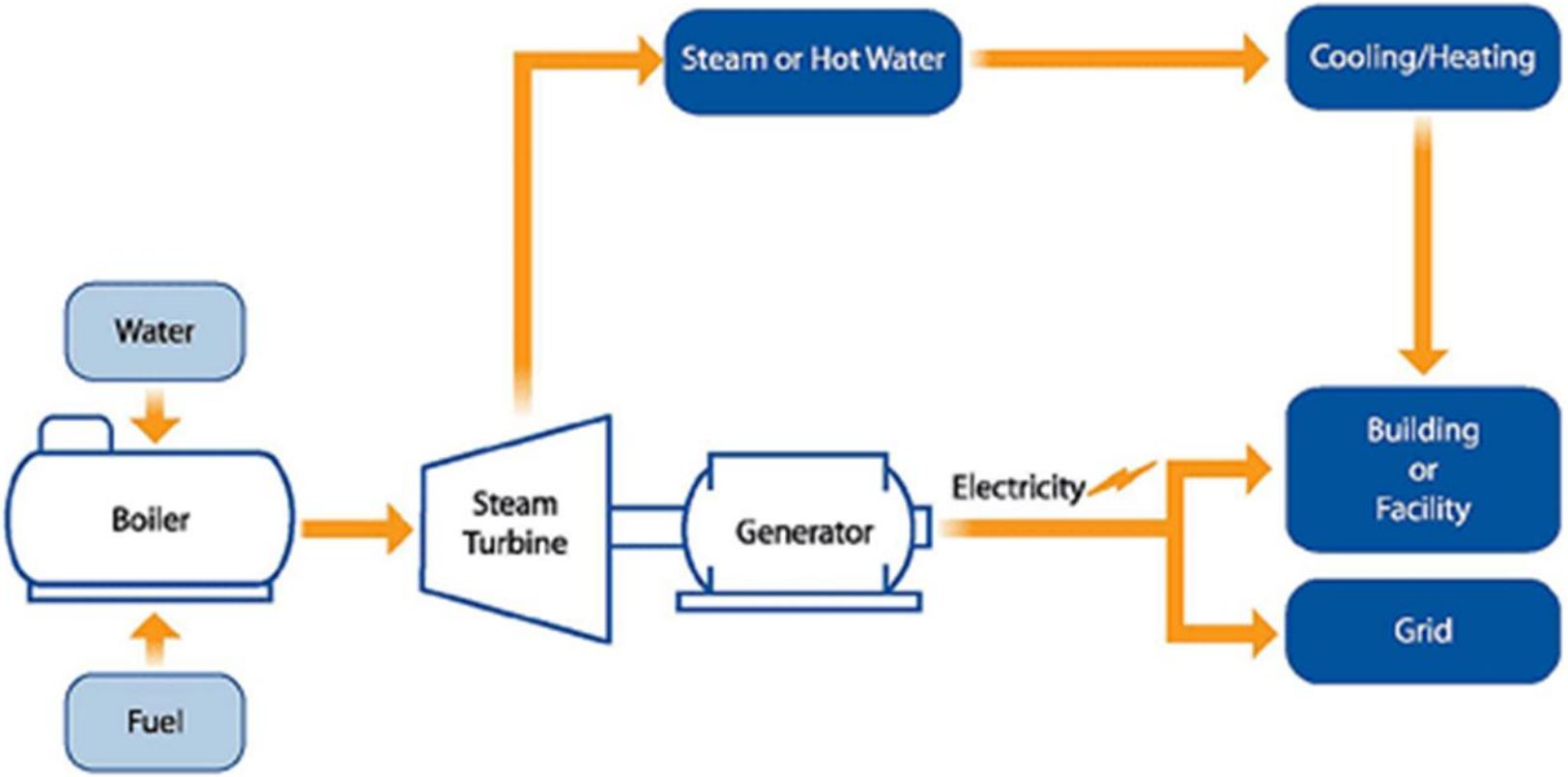
Source: NREL http://www.nrel.gov/dtet/about.html

What is Combined Heat and Power (CHP)?

- A method of simultaneously generating thermal energy (heat) and electricity
- Fuel agnostic
- Often in an integrated system
- Not a specific technology, but an application of currently available technologies
- Typically composed of mechanical components manufactured in the United States
- Flexible and resilient

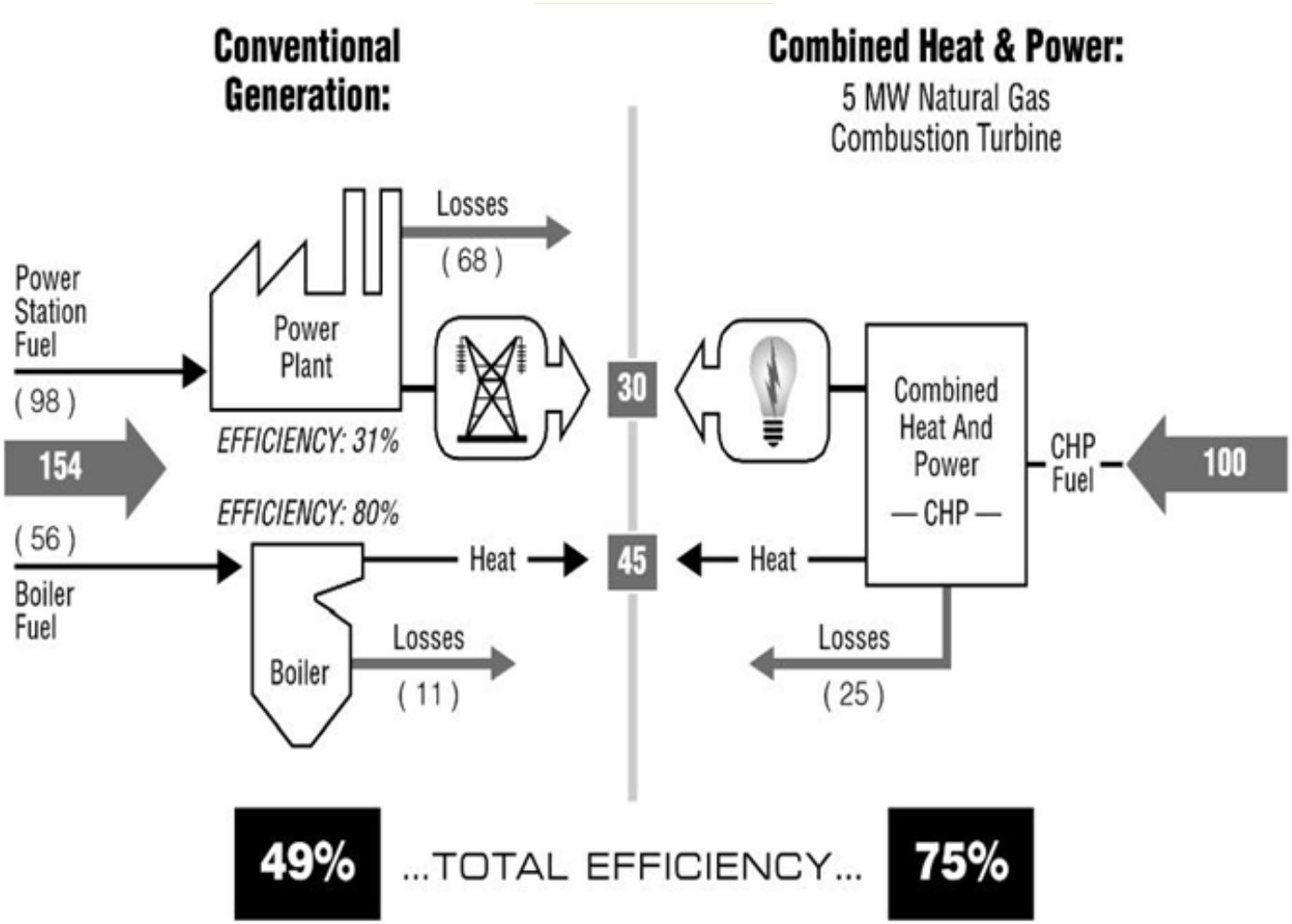
Source: ACEEE - http://www.aceee.org

How CHP Works



Source: www.combinedheatandpower.com

Increased Efficiency & Reduced Emissions

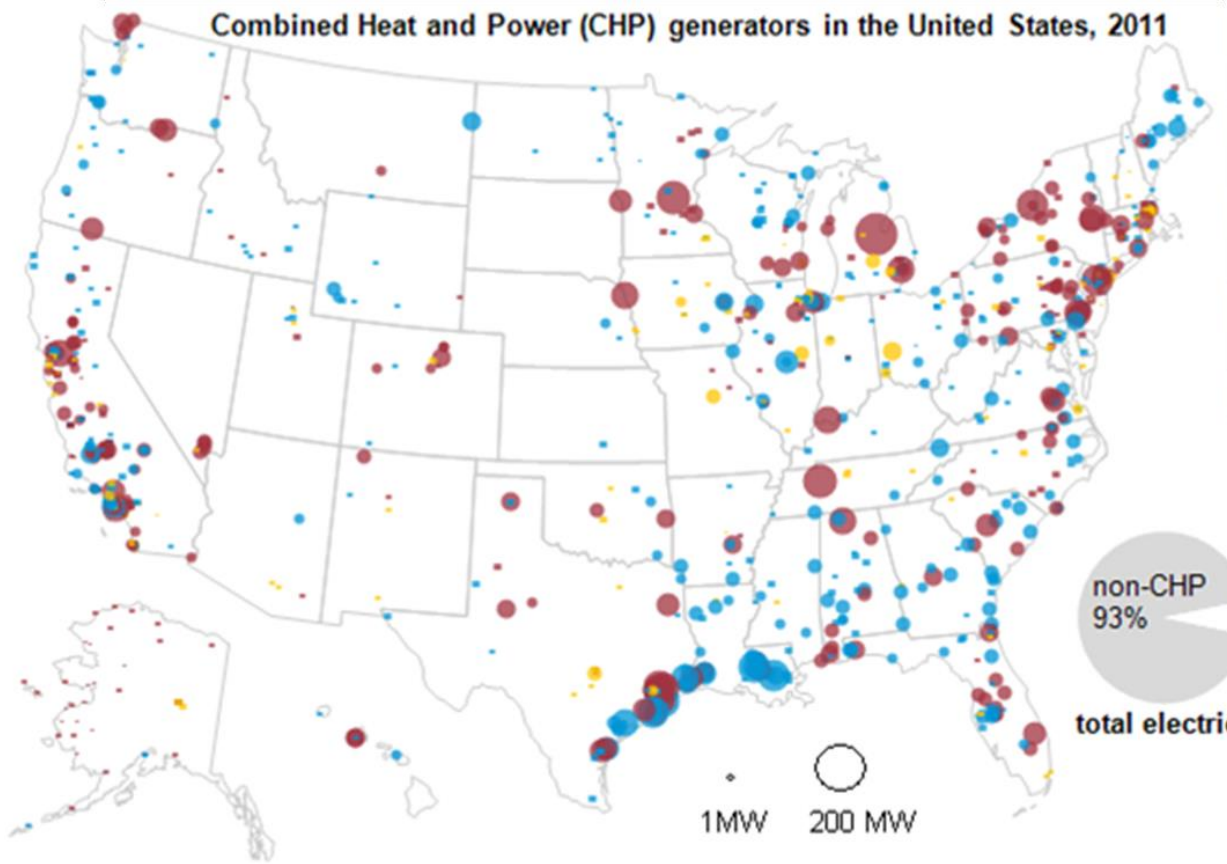


Applications for CHP

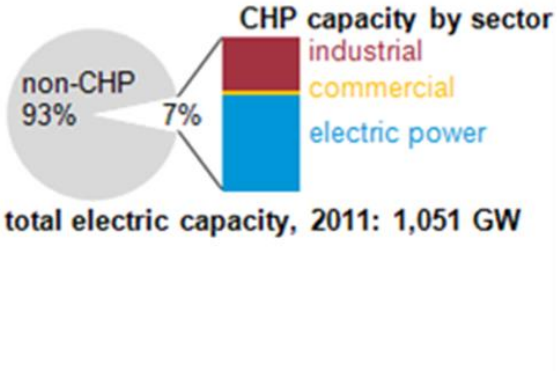
- Large CHP (>20 MW)
  - Industrial sites
  - Colleges and universities
  - Business districts with district energy systems
- Mid-Size CHP (1-20 MW)
  - High-growth industrial applications
  - Manufacturing and assembly plants
  - Institutional, military and government facilities
  - Large commercial sites
  - Business districts with district energy systems
- Small CHP (<1 MW)

Source: DOE Office of Energy Efficiency and Renewable Energy

CHP Generators



Rank	State	Total Capacity 2006 (MW)
1	TX	17,240
2	CA	9,220
3	LA	6,959
4	NY	5,789
5	FL	3,545
6	NJ	3,493
7	AL	3,362
8	PA	3,242
9	MI	3,104
10	OR	2,523



Source: U.S. Energy Information Administration, Annual Electric Generator Report

Benefits of CHP

- Uses existing, proven technology
- Improve system efficiency
- Diversify energy supplies
- Reduce emissions
- Increase business competitiveness
- Enhance resilience/energy security

Source: DOE Combined Heat and Power: Effective Energy Solutions for a Sustainable Future, 2008

Increasing the Security and Resilience of the Energy System

Forbes

William Pentland, Contributor
All electrons are not created equal.

ENERGY | 10/31/2012 @ 5:21PM | 4,670 views

Lessons From Where The Lights Stayed On During Sandy

It will likely take several days and possibly weeks before a small army of utility workers finish restoring electric service for customers without power across large swaths of New England and the Mid-Atlantic region, including those still in the dark in the Big Apple.

While the short term

CHP Kept Schools, Hospitals Running Amid Hurricane

Date: Dec 11, 2012

Above photo: Princeton University energy plant; view full gallery.

While Hurricane Sandy blew the lights out across much of New York City and the shorelines of New Jersey and Connecticut, some facilities in these areas stayed lit and warm through the use of combined heat and power (CHP).

CHP systems enabled buildings, hospitals, and entire campuses to retain full heat and power – even after losing grid-supplied electricity. This not only enabled these facilities to maintain critical operations during and after the storm, but also relieved the storm-stressed grid as electric utilities struggled to restore services.

Hurricane Timeline

After Hurricane Sandy hit the Caribbean Oct. 22, it swept the entire eastern seaboard. It made landfall near Atlantic City, N.J. and surged in New York City on Oct. 29, flooding subway lines and cutting power across the region.

How CHP Stepped Up When the Power Went Out During Hurricane Sandy

Like it? 8

Posted December 7, 2012 0 comment

Keywords: Electricity, Efficiency, Risk Management, chp, grid resiliency, Hurricane Sandy

7 25 2 +1 0 34

Lessons learned from Hurricane Sandy

02/11/2012
By Diarmaid Williams
International Digital Editor

While much attention is being devoted to where power was lost in New York and its surround this past week d storm, less focus has been placed on where the power was maintained.

Forbes describes the situation in those parts of the city that continued to be powered during Sandy in an articl **'Lessons From Where The Lights Stayed On During Sandy'** with cogeneration emerging with a great deal

William Pentland writes in Forbes, "the long-term strate Hurricane Sandy begins not where electric power was l

The New York Times
Dot Earth
ANDREW REVKIN

NOVEMBER 5, 2012, 6:11 PM

How Natural Gas Kept Some Spots Bright and Warm as Sandy Blasted New York City

By ANDREW C. REVKIN

As noted in recent blog posts by Forbes contributor William Pentland and the New York Times' Andrew Revkin, it's instructive to look at where the lights stayed on during Hurricane Sandy to understand what makes certain places more resilient than others.

Opportunity In Minnesota

- MN will add natural gas fired power plants
- This provides the opportunity to install CHP
  - Smaller distributed CHP
  - Large CHP - CCPP

The SGT5-8000H gas turbine developed by Siemens forms the heart of the highly efficient combined cycle power plant with district heat extraction in Düsseldorf, Germany. With an electrical unit output of around 595 megawatts (MW) and a net efficiency of over 61 percent, the Lausward CHP CCPP will set a new world. In addition, the generated thermal energy will be used for the district heating system in the city of Düsseldorf. The overall efficiency of the natural gas fuel will be around 85 percent.

ACEEE 2012 Scoring of MN's CHP Policy

Factor	MN	AVG of Top 10
Standard interconnection rules (1pt)	0.5	0.75
CHP/waste heat recovery in standards (RPS, EERS) (1pt)	0.5	0.6
Applicable financial incentive programs (1pt)	0	0.7
Favorable net metering regulations (0.5pt)	0	0.05
Output-based emissions regulations (0.5pt)	0	0.45
Loan and loan guarantee programs (0.5pt)	0	0.2
Supportive policies (0.5pt)	0	0.15
Total	1	2.9

Thank You

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